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MAGNETIC BONE CONDUCTION AND EARDRUM OSCILLATION
MICROPHONE IN COMMON USE OF TRANSMISSION AND RECEPTION
[Sojuwa Soyogata Denjishiki Hone Dando
Komaku Shindo'on Maikurohon]

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1. Title of the Invention

MAGNETIC BOND CONDUCTION AND EARDRUM OSCILLATION MICROPHONE IN COMMON
USE OF TRANSMISSION AND RECEPTION

2. Claim(s)

(1) A magnetic bone conduction and eardrum oscillation microphone in common use of transmission and reception characterized by being equipped with a diaphragm which transmits the oscillation of a surface of a living body mechanically, a power-generating mechanism arranged opposite said diaphragm, a sound guide connected to an air line formed from said diaphragm and a case having an airtight structure, and an ear chip provided at the tip of said sound guide to be able to mix and pick up, with one diaphragm, the bone conduction sound from the surface of a living body as well as the eardrum oscillation detected in an airtight system by the external auditory canal, and also, receive it as a bone conduction receiver and an airtight earphone.

(2) The magnetic bone conduction and eardrum oscillation microphone in common use of transmission and reception of Claim 1 characterized by the oscillation of the surface of a living body being conducted directly to the diaphragm via an outer skin contact chip.

(3) The magnetic bone conduction and eardrum oscillation microphone in common use of transmission and reception of Claim 1 characterized by the oscillation of the surface of a living body being conducted to the aforementioned diaphragm via an external main body case and a suspension.

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(4) The magnetic bone conduction and eardrum oscillation microphone in common use of transmission and reception of Claim 1 characterized by the oscillation of the surface of a living body being conducted to the aforementioned diaphragm via an outer skin contact chip and a suspension.

(5) The magnetic bone conduction and eardrum oscillation microphone in common use of transmission and reception of any of Claims 1 to 4 characterized by the aforementioned power-generating mechanism comprising a moving coil fixed to the aforementioned diaphragm, and a core and /476 permanent magnet arranged opposite said moving coil.

(6) The magnetic bone conduction and eardrum oscillation microphone in common use of transmission and reception of any of Claims 1 to 4 characterized by the aforementioned power-generating mechanism being comprised of a moving iron piece fixed to the aforementioned diaphragm, and a core, permanent magnet and power-generating common excitation coils.

3. Detailed Specifications

This invention relates to a magnetic bone conduction and eardrum oscillation microphone in common use of transmission and reception which manifests an especially large effect under high noise.

Direct- and acceleration-type magnetic bone conduction microphones have been known in the past. Figure 1 shows an example of a direct-type magnetic bone conduction and eardrum oscillation microphone. 1 in the drawing is a core; 2 is a power-generating coil; and 3 is a permanent magnet. In addition, 4 is a suspension; 5 is a screw; 6 is an oscillation plate comprising a magnetic substance; and 7 is an outer skin contact

¹Number in the margin indicates pagination in the foreign text.

ship. As seen from the drawing, the suspension 4 is mounted to the frame of the core 1 with the screw 5, while the oscillation plate 6 and the outer skin contact chip 7 are anchored to this suspension 4.

If a surface of a living body is oscillated by a bone conduction sound, this oscillation is conducted directly to the outer skin contact chip 7 and oscillation plate 6, and converted to an electric signal in a microphone having such a configuration. Thus, it has a merit because the bone conduction sound can be picked up efficiently. However, it has a drawback because the operating point readily changes if the force of the pressure on the surface of a living body varies.

If the shear modulus of the suspension 4 is increased as a measure to counter this, an oscillation system comprising the suspension 4, oscillation plate 6 and outer skin contact chip 7 responds to the high-frequency components of the bone conduction sound, but it hardly responds to low-frequency components. Thus, the low-frequency components of the sound picked up by this microphone are insufficient, and a drawback developed because the sound was unnatural.

An example of a conventional acceleration-type magnetic bone conduction and eardrum oscillation microphone is described next in Fig. 2. In the drawing, 8 is a main body case; and 9 is a cover mounted to this main body case 8 with a screw. 10 is a diaphragm which is anchored to the center of the suspension 4 and the center portion thereof has very high rigidity. The oscillation plate 6 comprising a magnetic substance is anchored to the center of this diaphragm 10. Meanwhile, the core 1 is

mounted to the peripheral portion thereof. The power-generating coil 2 and the permanent magnet 3 are fixed to the core 1.

If the surface of a living body oscillates in accordance with a bone conduction sound in the accelerated-type magnetic bone conduction and eardrum oscillation microphone having such a configuration, the entire main body case 8 mounted to the surface of the living body oscillates in accordance with that oscillation. If the main body case 8 oscillates, this oscillation acts on the oscillation plate 6 by way of the suspension 4. At this time, the mass of the core 1, power-generating coil 2 and permanent magnet 3 increases and so does the inertial moment; hence, they do not, while only the diaphragm 10 oscillates. Consequently, the distance between the oscillation plate 6 and the projection of the core 1 changes, while the magnetic resistance of the magnetic circuit changes; hence, the bone conduction sound is converted to an electric signal.

This type of microphone has a merit because the operating point does not change at all even if the force of the pressure on the living body changes. However, this microphone has a drawback because a natural sound cannot be picked up since the attenuation of the low-band components was increased to design the diaphragm 10 so as to set the resonance point in the high band for readily detecting the high-frequency components sufficiently.

In addition, conventional magnetic bone conduction and eardrum oscillation microphones are dedicated either to transmission or reception; no device used for both transmission and reception has existed.

An object of the present invention is to provide a magnetic bone

conduction and eardrum oscillation microphone in common use of transmission and reception for eliminating the drawbacks of the above-mentioned /477 conventional devices, to thus expand the register that may be picked up and enable reproduction of a natural sound by being able to simultaneously pick up bone-conducted high-band sound and eardrum-oscillated low-band sounds, and also, be able to perform both transmission and reception, and further, does not pick up noise when used under high noise.

The characteristic feature of the present invention include the fact that a diaphragm which transmits the oscillation of a surface of a living body mechanically, a sound guide connected to an air line formed from said diaphragm and a case having an airtight structure, and an ear chip provided at the tip of said sound guide are provided to be able to mix and pick up, with one diaphragm, the bone conduction sound from the surface of a living body and an eardrum-oscillated sound, and also, receive it.

The present invention will now be described through the practical examples. Figure 3 illustrates the 1st practical example of the present invention. In this drawing, 11 is a main body case; 12 is a cover anchored to this main body case 11 with a screw 13; 14 is a diaphragm clamped between the main body case 11 and cover 12; 15 is a mounting screw whose head portion is anchored to nearly the center of the diaphragm 14; 16 is an outer skin contact chip anchored by screwing in this mounting screw 15; and 17 is a moving coil which is anchored to the opposite side of the outer skin contact chip 16 of the diaphragm 14. In addition, 18 is a mounting member having a plurality of air holes 19; 20 is a permanent magnet fixed to this mounting member 18; and 21 is a core. Furthermore,

the space formed by the main body case 11 and the diaphragm 14 is done so as airtight structure, while a sound guide 23 is mounted to the air hole 22 of the main body case 11. Moreover, an ear chip 24 is provided at the tip of the sound guide 23. Furthermore, a damper 25 comprising a ^{ASK} sponge or the like is inserted between the diaphragm 14 and the cover 12. 26 is a lead wire.

Even if the sound guide 23 here is a soft material and deformed readily, its capacity does not change at all. For example, it is made from a pipe comprising a vinyl or silicone resin or the like concealing a helical coil made of metal. In addition, the diaphragm 14 is formed from a metal plate, resin film, and the like on which concentric recesses and projections are provided so that the oscillation can be captured sensitively. But when the microphone of this practical example is mounted to a surface of a living body, it can be made with enough strength so that the operating point remains unchanged by a force of pressure.

The operation of this practical example is described next. First of all, the outer skin contact chip 16 of the microphone of this practical example is contact against a surface of a living body, and also, the ear chip 24 is inserted into an ear hole. Now, assuming a bone conduction sound is transmitted by way of bone and subcutaneous tissue, the surface of a living body is oscillated by this bone conduction sound. This oscillation is then propagated to the diaphragm 14 via the outer skin contact chip 16. At this time, the mechanical inductance of the system comprising the diaphragm 14, mounting screw 15 and outer skin contact

chip 16 is chosen so as to match the inductance synthesized by bone, subcutaneous tissue and the living body at the time of contact to better the efficiency of the bone conduction sound pickup. Therefore, the percentage of the low-band of the bone conduction sound that is attenuated is larger than the high-band. In addition, more high-band sound components are contained than low-band components in the bone conduction sound. Thus, the percentage of the high-frequency components in the bone conduction sound of oscillation applied to the diaphragm 14 via the outer skin contact chip 16 is high.

Meanwhile, the eardrum is oscillated by the air sound in the oral cavity directly by way of the Eustachian tube, etc. Since the mechanical inductance of the eardrum is low, the sound picked up by the eardrum is not a bone conduction sound and it has low-band components. Thus, the low-band components of the sound are propagated into the main body case 11 via the sound guide 23, then to the diaphragm 14 via the plurality of air holes 19 provided in the mounting member 18.

As a consequence, the high-band components of the bone conduction sound are inputted into the diaphragm 14 via the outer skin contact chip 16, and the low-band components are inputted via the sound guide tube /478 23; hence, the diaphragm 14 performs oscillation comprising the high-band of the bone conduction sound and the low-band of the eardrum oscillation. Thus, the band of the picked-up sound can be broadened, and a more natural sound can be converted to an electric signal.

Incidentally, the results of the measurements by the inventors of the present invention will be described with reference to Fig. 4. Figure

4(a) shows a sound waveform of a case in which the Japanese vowels "a, e, i, o and u" are picked up by an ordinary capacitor microphone. Moreover, Fig. 4(b) shows sound waveforms a case in which the sound guide 23 in Fig. 3 is not used, that is, only the bone conduction sound is picked up from the outer skin contact chip 16; the sound waveform of, in contrast to Fig. 4(b) above, Fig. 4(c) having the same sound as in Fig. 4(a) shows a sound waveform of the Japanese vowels "a, e, i, o, u" in a case in which the sound is picked up from the sound guide 23 only by inserting an ear chip 24 into the ear hole; while Fig. 4(d) shows a sound waveform of a case in which the bone conduction sound is picked up from both the outer skin contact chip 16 and the ear chip 24.

It is evident that the sound waveform (d) in a case in which the bone conduction sounds from both the outer skin contact chip 16 and ear chip 24 is the closest to the sound waveform (a) of the capacitor microphone among the microphones in Figs. 4(a), (b), (c) and (d). Therefore, it can be said that a more natural sound can be picked up by the microphone of this practical example.

Although the above description is a case in which the microphone of this practical example is used as a transmitter, an operation in which it is used as a receiver is described next.

If the electrical sound signal is propagated to the moving coil 17 via a lead wire 26, the diaphragm 14 oscillates at the same [illegible] as that of an ordinary speaker, whereupon oscillation of the air occurs. This oscillation is propagated to the sound guide 23 and to the eardrum of the ear via the plurality of air holes 19 provided on a support member

18. In addition, if the diaphragm 14 oscillates, this oscillation is propagated to the surface of the living body contacted via the outer skin contact chip 16 and then through the bone tissue. As a consequence, the sounds from both the eardrum and the bone tissue can be sensed. Moreover, the conductance system of a person engaging in noisy work often becomes impaired over a long period of time, and the sensitivity of an ordinary person often drops about 20 to 40 dB. Reception by such an impaired person of the bone conduction sound is effective.

According to the microphone in common use of transmission and reception of this practical example, the mechanical impedance of the diaphragm 14 is by far larger than that of the air. In addition, since the sound guide 23 is fabricated from vinyl or silicone resin or the like concealing a helical coil fabricated from a metal, as mentioned previously, the air sounds from the outside hardly enter the main body case 11 through the sound guide 23. Thus, even if the microphone of this practical example is used under high noise, the noise is not picked up at all.

In addition, since the sound guide tube is formed from the material as described above, impulsive sounds from the main body case 11 that are propagated inside the sound guide 23 are attenuated. Moreover, since the damper 25 is provided between the diaphragm 14 and the cover 12, the diaphragm 14 is prevented from being oscillated by the impulsive sounds of this main body case 11. As a consequence, it can be said that the microphone of this practical example can withstand the impulsive sounds of the main body case.

The 2nd practical example of the present invention is described next with reference to Fig. 5. The places where this practical example differs from the 1st practical example merely include the fact that a moving iron piece 27 is mounted to the center of the diaphragm 14 and a power-generation and excitation coil 28 is anchored to the amplifier 21, while the other parts are the same. In addition, the effects of this practical example also are the same as those of the 1st practical example.

Figure 6 depicts the 3rd practical example of the present invention. Whereas the 1st practical example depicted in Figure 3 involves the direct-type magnetic bone conduction and eardrum oscillation microphone in common use of transmission and reception, this practical example differs from the 1st practical example in that it is an acceleration-type microphone.

31 in Fig. 6 denotes an external main body case, 32 denotes a /479 cover; 33 denotes a screw; 34 denotes a suspension comprising a metal plate, such as an iron plate, having very high rigidity and which is clamped between the external main body case 31 and the cover 32; 35 denotes a screw; 36 denotes a diaphragm coupled to the center of the suspension 34 by anchoring the center thereof and the head portion of the screw 35; 37 denotes an internal case; and 38 denotes a sound guide connection tube having a flexible structure fabricated from the same material as the sound guide 23. The other reference symbols denote the same or equivalent objects in Fig. 3.

The diaphragm 36 here is formed from a resin film with concentric recesses and projections. Thus, the moving coil 17 mounted on the diaphragm

36 has a structure free a resonance point and specific strength to readily act on the permanent magnet 20 and the core 21.

Now, at the time of use, the cover 32 is contacted against the surface of a living body and the ear chip 24 is inserted into an ear. When a bone conduction sound is transmitted through the bone tissue, the surface of a living body oscillates depending this bone conduction sound, and the cover 32 and the external main body case 31 oscillate depending on the oscillation of the surface of the living body. Moreover, since the

Note
the diaphragm is made of thin film
shear modulus of the suspension 34 is very large, the suspension 34 moves similarly to the cover 32 and the external main body case 31. However,

the power-generating mechanism held in the main body case 37 supported by the diaphragm 36 increases in mass. Since the inertial moment is large, it does not move regardless of the oscillation of the aforementioned surface of a living body. Thus, the moving coil 17 oscillates dependent on the bone conduction sound between the permanent magnet 20 and the projections of the core 21, and an electric signal is outputted to the lead wire 26.

Because the resonance point of the diaphragm is set to enhance the clarity of the sound picked up from such a surface of a living body, as mentioned above, attenuation of the low-band of the sound is high.

Meanwhile, a sound able to be picked up from the eardrum is inputted from the ear chip 24. This sound picked up from the eardrum has a large amount of low-band components, as described in the 1st practical example section.

Thus, with the diaphragm 36, the high-band components of the bone

conduction sound picked up from the surface of a living body and the low-band components picked up from the eardrum are synthesized, so a natural sound can be picked up.

When the microphone of this practical example is used as a receiver, the electric signal of the sound is inputted into the moving coil 17 from the lead wire 25, whereupon the suspension 34 and the external main body case 31 oscillate, and at the same time, the permanent magnet 20, core 21 and main body case 37 oscillate. Thus, the air in the internal case 37 oscillates, and the oscillation of this air reaches the eardrum through the sound guide connection tube 38 and the sound guide 23. Thus, the microphone can be used as a receiver.

The microphone of this practical example has a merit because the operating point does not vary at all, as compared to the microphones of the 1st and 2nd practical examples. Moreover, the other effects are substantially the same as those of the 1st and 2nd practical examples.

The 4th practical example of the present invention is described next with reference to Fig. 7. This practical example is an eclectic-type of the direct-type of the 1st practical example and the acceleration-type of the 3rd practical example; it can be a combined acceleration- and a direct-type. 34' in the drawing denotes a suspension and 39 is a cover mounted to the external main body case 31 with a screw 33. The other reference symbols denote the same or equivalent objects in Fig. 6.

As shown in Fig. 8, the suspension 34' here is composed of a metal plate 34a having a punched part 34b in a form where a sufficient stroke is acquired from the center to the circumference. In addition, a plurality

of screw insertion holes 34c are formed in the metal plate 34a. A metal plate having a high shear modulus, e.g., a beryllium copper plate is used as the diaphragm 14.

The outer skin contact chip 15 of the microphone of this practical example, at the time of use, is contacted against the surface of a living body, and the ear chip 24 is inserted into an ear hole. The high-band components of the bone conduction sound, as evident from the description in the 1st practical example, are propagated to the diaphragm 36 via /450 the outer skin contact chip 15. Meanwhile, the low-band components of the bone conduction sound are propagated to the diaphragm 36 from the ear chip 24 via the sound guide 23 and the sound guide connection tube 38. Thus, the pickup signal of a more natural containing the high-band of the bone conduction sound and the low-band of the eardrum oscillation is outputted along the lead wire 26.

The fact that the microphone of this practical example can be used as a receiver is evident with reference to the descriptions of the 1st and 3rd practical examples.

This microphone, as previously stated, is an eclectic-type of the direct-type and acceleration-type; hence, it has the advantages of each type. That is, it has merits because the bone conduction sound of the direct-type can be picked up efficiently and the operating point remains the same. Moreover, in addition to these merits, it has substantially the same advantages as those described in the 1st practical example.

The 3rd and 4th practical examples above were described as examples in which a moving coil was used as the power-generating mechanism, but

it is evident that the power-generating mechanism presented in the 2nd practical example, e.g., a power-generating mechanism using a moving iron piece may be used.

As has been described above, according to the present invention, since the low-band components of the bone conduction sound are picked up from the ear chip inserted into an ear hole and this is applied to the ear drum; hence, a more natural sound can be picked up than with a conventional electromagnetic-type bone conduction sound microphone. In addition, it also can be used as a receiver, which is extremely convenient. Furthermore, since external sounds are not picked up even under high noise, the S/N is large, and moreover, there is a major advantage because there is no risk of howling.

4. Brief Description of the Drawings

Figure 1 is a cross section of a conventional direct-type electromagnetic bone conduction and eardrum oscillation microphone; Figure 2 is a cross section of a conventional acceleration-type microphone; Figures 3, 5, 6 and 7 are respective cross sections of the 1st, 2nd, 3rd and 4th practical examples of the present invention; Figure 4 is a sound waveform for describing the effects of the 1st practical example; and Figure 8 is a plan view of the suspension.

14, 36: diaphragms; 16: outer skin contact chip; 17: moving coil; 20: permanent magnet; 21: core; 23: sound guide; 24: ear chip; 27: moving iron piece; 28: power-generation and excitation coil; 34, 34': suspensions; 38: sound guide connection tube

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